

**NETWORK INSTALLATION IN THE YANQING-HUAILAI BASIN AND PRELIMINARY STUDY OF  
NATURAL AND MAN-INDUCED EVENTS**

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**ABSTRACT**

Southern Methodist University and the Institute of Geophysics of the China Seismological Bureau are carrying out “a comparative study of natural and man-induced seismicity in the Yanqing-Huailai basin and the Haicheng area”. The geographic focus of this investigation is in the Yanqing-Huailai Basin, 120 km northwest of Beijing. Within the Yanqing-Huailai Basin, earthquake risk and propagation path assessments are important because of the basin's historical seismicity and Beijing's large population. Numerous underground mines in the region regularly experience rock bursts and collapses resulting in the disruption of mining operations, injury and occasionally death. The objectives of this project are to develop a dataset of near-source and regional waveforms that may be used to study natural and man-induced seismicity as well as regional wave propagation and source characterization constraints. The instrumentation deployed consists of four stations around and within the basin for source location and characterization, four stations at near-regional and seven stations at regional distances. IRIS (Incorporated Research Institutes for Seismology) PASSCAL Seismological Instrumentation Center provided STS-2 broadband seismometers and the new Quanterra Q330 digitizer and PB14 Baler recording systems. Each station includes two hand-dug vaults in hard rock; one for the STS-2 seismometer and one for the Quanterra system, power supply, and batteries. In the fall of 2002, five stations were deployed in and around the basin followed in the spring of 2003 by eight stations at regional distances. Two additional stations are planned in the summer of 2003. The data from the first five stations has been collected and exchanged between SMU and IGCSB. Local network bulletins for the Huailai Basin and the adjoining region indicates that this area has had active seismicity since installation. Two mine blasts at close distance, a regional event from a 1.3-kiloton mine explosion, and a teleseismic event from southwest Alaska are used to illustrate data quality.

## OBJECTIVES

The goals of this collaborative study between Southern Methodist University (SMU) and the Institute of Geophysics, China Seismological Bureau (IGCSB) are to develop an earthquake and man-induced event database to refine event locations in Yanqing-Huailai Basin, to understand source characterization of natural and man-induced events, and to separate source and propagation path effects at regional distances. These goals contribute to earthquake risk assessments and mine safety issues, and this synergy motivated the collaborative empirical study (Stump et al., 2002). The region of focus is the Yanqing-Huailai Basin near Beijing.

The purpose of this experimental study is to compare natural and man-induced seismicity in the Yanqing-Huailai Basin, NW of Beijing (Figure 1). It is a region of historical natural and man-induced seismicity as well as a seismic hazard for Beijing. A broadband seismic network has been designed to provide near-source and regional coverage. Four seismic stations have been installed in the immediate vicinity of the basin (XJYAO, BAKOU, AYPU, and CJPU). Four near-regional stations surround the basin (ZSPO, YFANG, MJPU, and IGCSB). The seven additional stations are at regional distances. The first five stations were installed in Nov. 2002. Seismic events (dots) for the time period 20 Nov. 2002 through 05 May 2003 are superimposed on the map and illustrate the activity in this region. Triangle denotes the station that will be installed in the summer of 2003.

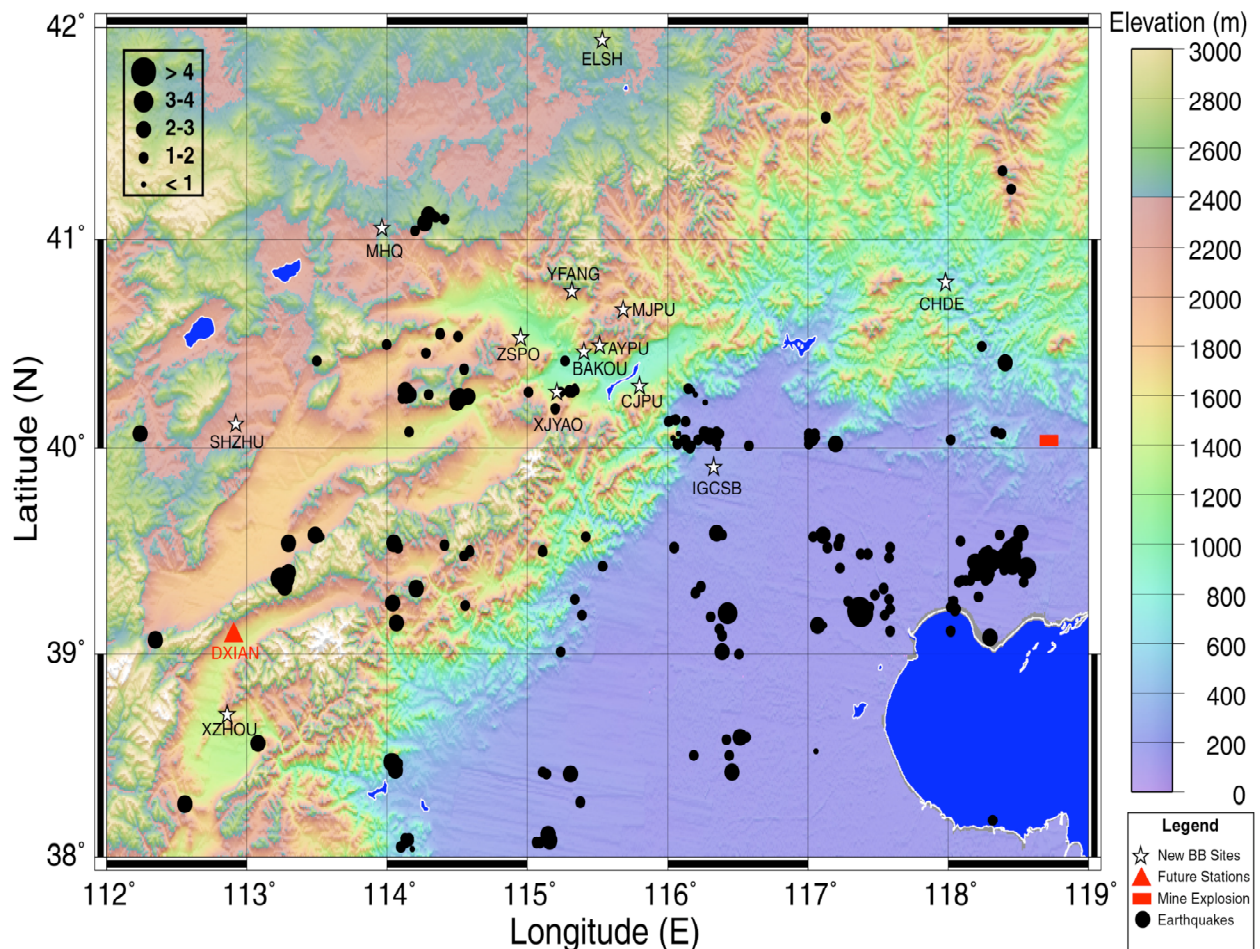


Figure 1. Topographic map of study area with the geographic distribution of 13 broadband seismic stations (stars) superimposed with regional seismicity (dots, magnitude 0.4 to 4.3) for time period of 20 Nov. 2002 and 5 May 2003. The triangle is the station that will be installed and the rectangle is location of the mine explosion used to illustrate data quality.

## **RESEARCH ACCOMPLISHED**

### **Station Instrumentation, Design and Installation**

#### **Station Instrumentation**

A joint SMU/IGCSB/IRIS team designed the station vaults, tested the new equipment (Summer 2002), and did the initial station installation in November 2002. IRIS PASSCAL provided STS-2 seismometers, Quanterra Q330 data acquisition systems, and Quanterra PB14 Packet Balers for this experiment (Figure 2). This is the first field deployment of these systems. The Quanterra Q330 includes ultra-low-power delta-sigma 24-bit A/D with DSP, 8 Mb RAM, a GPS receiver, power management, sensor control, and telemetry management. As a data recording system, Quanterra PB14 Packet Baler stores up to 20 Gb of data in miniSEED format.



**Figure 2. STS-2's, Quanterra 330's and Baler PB14's during huddle test in Beijing, China.**

#### **Station Design and Installation**

The seismic vaults were designed to house both the seismometer and data acquisition equipment. The vault was designed to reduce tilts at long periods, to provide temperature stabilization, and to isolate the equipment from water, dust, and dirt. Each installation consisted of two hand-dug 1-m  $\times$  1-m  $\times$  1-m vaults; one for the seismometer and one for the data acquisition system (Figure 3 and 4). The vaults were all in hard rock and were connected by a conduit for cabling. The seismometer was covered with a 10-cm-thick foam box for additional temperature stabilization. Figure 3 documents the installation at AYPY. Figure 4 is the overview of the XJYAO and BAKOU stations.





**Figure 3. Left: Vault for STS-2 (upper) and Quanterra (Lower); Right: The installation team at work at AYPU**



**Figure 4. Overview of BAKOU (Left) and XJYAO (Right) station including two vaults for STS-2 and Quanterra system, solar panel for power supply.**



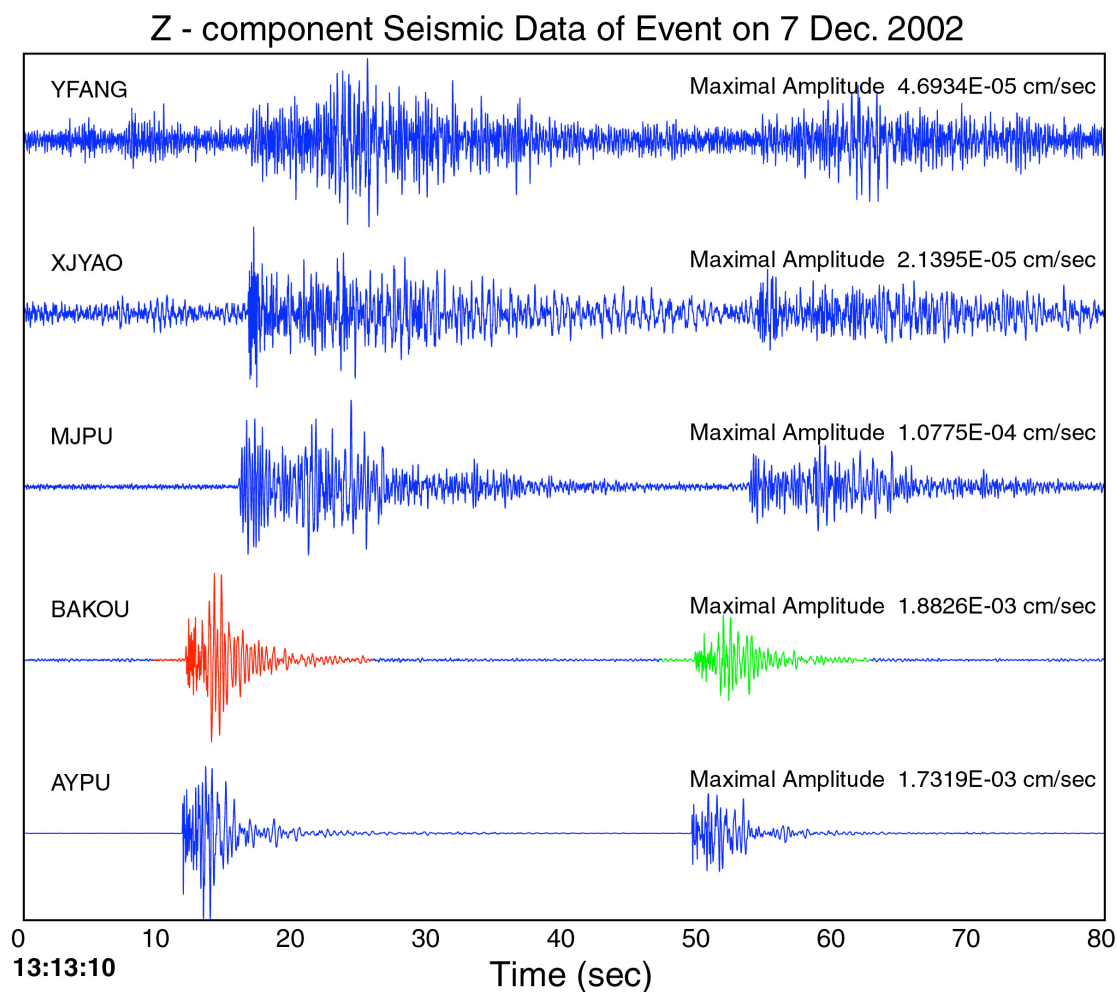
Data is archived locally at each site. Periodic visits to the sites provide the opportunity to retrieve the data where it is stored on a Sun Ultra 10 at IGCSB; Beijing. Data is transferred to SMU by ftp and disk exchange.

### Data

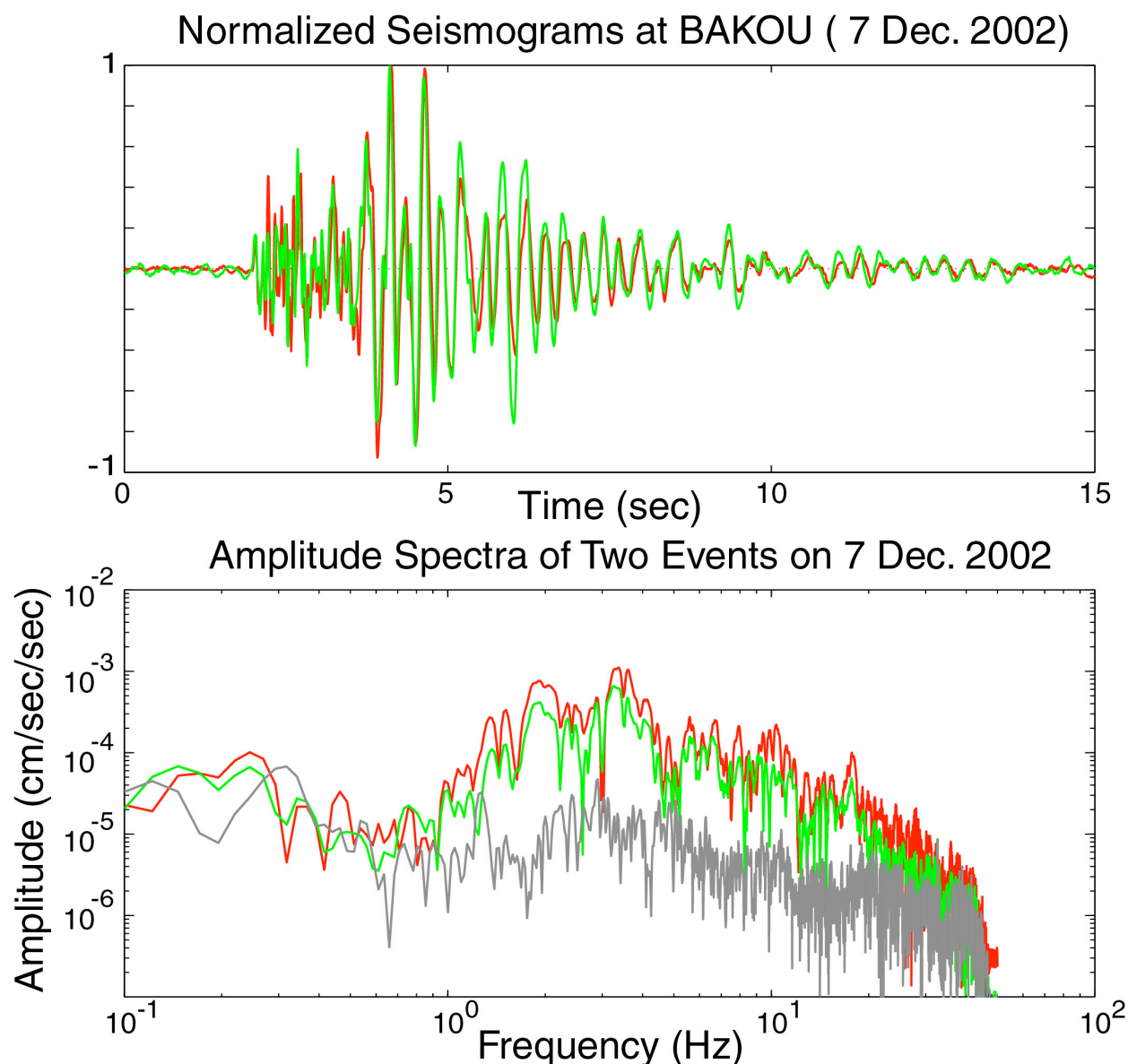
Local, regional, and teleseismic signals recorded by the first five stations illustrate the operation of the new network and instruments. These examples include a range of natural and man-induced events.

### **Local Events**

Around the Yanqing-Huailai basin, frequent industrial explosions and rock bursts occur in numerous above and underground mines. Figure 5 is an example of two events separated by 37 seconds, and both were identified as mining explosions. Figure 6 is the superposition of the two seismograms at BAKOU from the two repeated events and their nearly identical spectra. Although the nearly identical waveforms indicate a common location and source, the spectra show a slight size difference between events. These events from the same location are well recorded by our network and occur approximately once a day. The signal-to-noise ratio is a factor of 100 from 1–20 Hz. The good signal-to-noise ratio from these repeated events will help us to understand the source and local propagation path characteristics over a broad frequency range. This example illustrates the high frequency response of the STS-2 and Quanterra recording system.



**Figure 5. Z-component seismograms from the mining explosions.**



**Figure 6.** Upper: superposition of two events recorded at station BAKOU. Lower: spectra of two events (red and green) and noise (gray).

### Regional Event

Eastday reported (<http://news.eastday.com/epublish/gb/paper148/20021230/class014800003/hwz854971.htm>) a 1.3-KT yield explosion (Figure 7, upper) fired on 29 Dec. 2002, at an iron mine in QianAn (the largest open-pit iron mine in Asia from <http://www.qian-an.gov.cn/qasgk/dlhj.htm>), 270 km southeast of Huailai Basin (red rectangle in Figure 1). This explosion is the largest engineering explosion in China for the last decade. The duration of the pattern was reported to be 1.3 seconds. The USGS NEIC reported the magnitude of  $m_b$  3.5. The seismograms at four stations from our network are reproduced in Figure 7 (lower). XJYAO had an outage for this event. The signals are rich in high-frequency body waves and intermediate-period surface waves. The bandpass filtered data (Figure 8) quantifies the frequency characteristics of the P wave, Lg wave, and surface wave.





Z - component Seismic Data of QianAn Event on 29 Dec. 2002

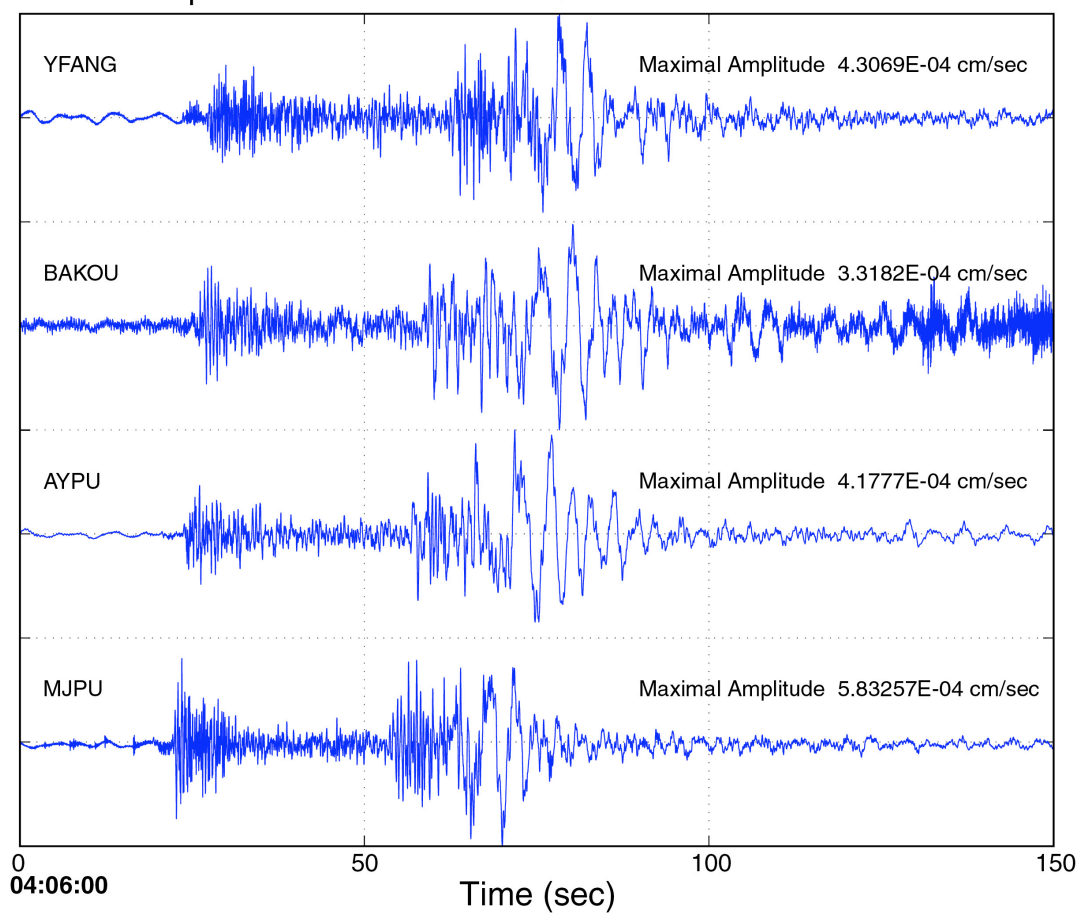
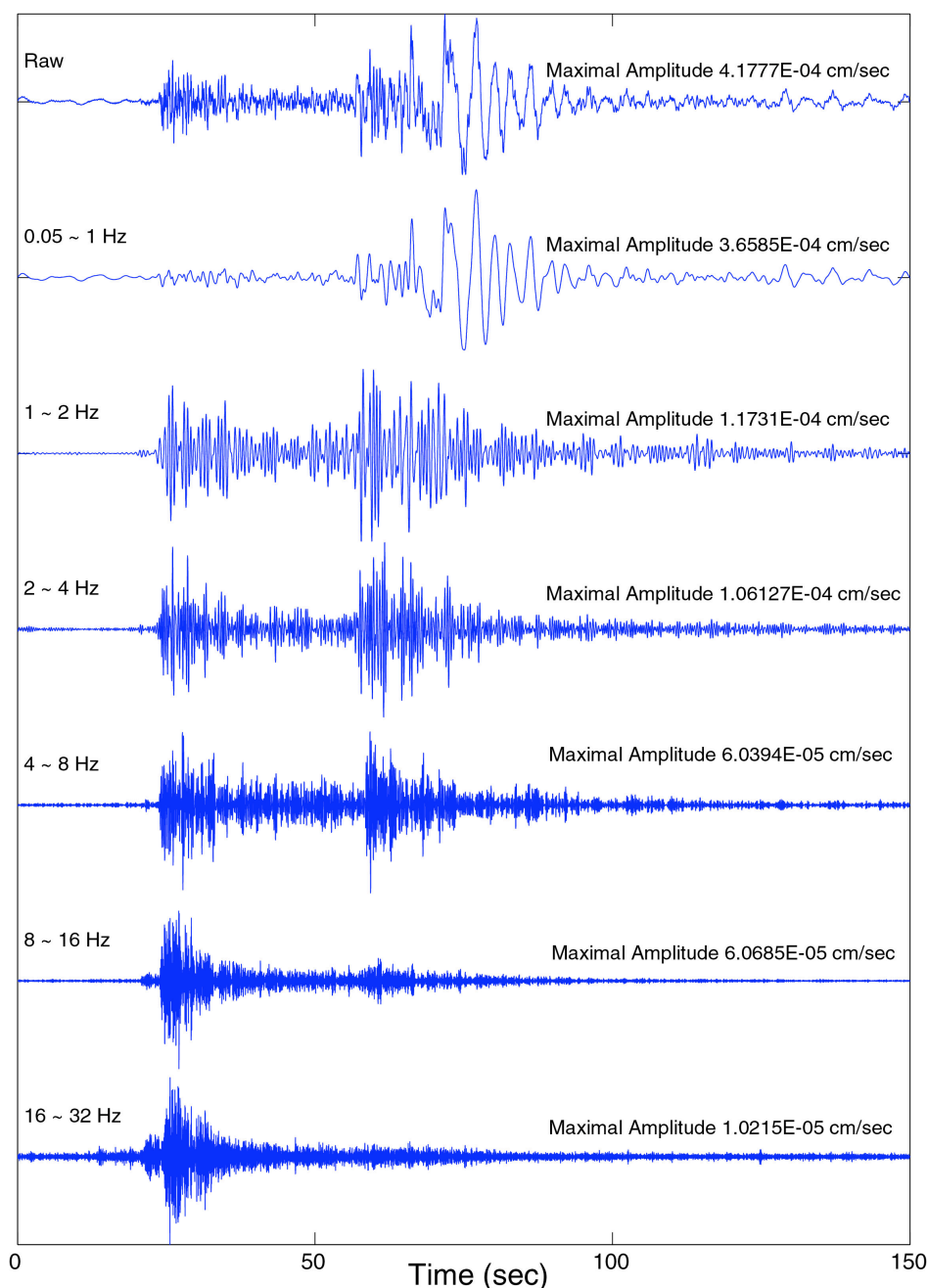


Figure 7. Top: Photo from media showing the explosion on 29 Dec. 2002. Bottom: Seismograms from the explosion at four stations

### AYPU for event on 29 Dec. 2002

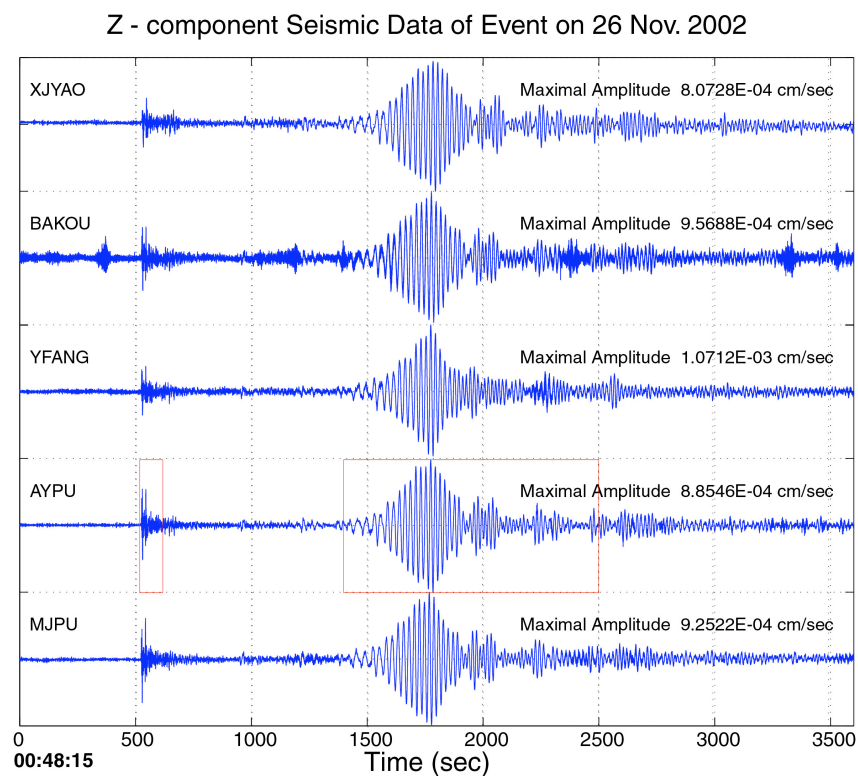


**Figure 8. Spectral composition of QianAn event on 29 Dec. 2002 recorded at AYP.**

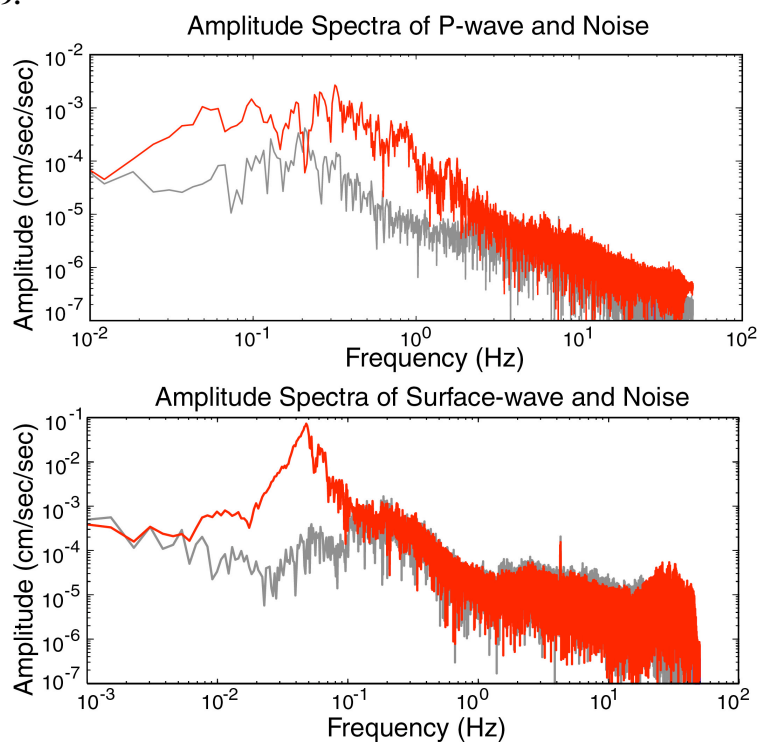
#### Teleseismic Event

A magnitude 5.9 earthquake at  $51.465^{\circ}\text{N}$ ,  $173.537^{\circ}\text{W}$ , southwest of Alaska, on 26 Nov. 2002 (USGS NEIC), was the first large earthquake recorded by our network. The epicentral distance to the network was about 48 degrees, and the seismograms are displayed in Figure 9. The signal-to-noise ratio for the P-wave and surface-wave at AYP are presented in Figure 10. The signal (red) to noise (gray) ratios are a factor of 100 over the period range of 1–30 sec and 10–100 sec for P-wave (Figure 10, upper) and surface-wave (Figure 10, lower), respectively.





**Figure 9. Seismograms from a teleseismic event occurred at southwest of Alaska on 26 Nov. 2002 with a magnitude 5.9.**



**Figure 10. Top: Signal-to-noise ratio for P-wave (red: signal; gray: noise) Bottom: Signal-to-noise ratio for surface wave (red: signal; gray: noise)**

## **CONCLUSIONS AND RECOMMENDATIONS**

As the first field deployment of Quanterra system, the initial operation has highlighted several problems. During testing at SMU and prior to installation, data in the Baler could not be displayed and downloaded completely. A software update solved the problem. The Baler has had some outages at stations YFANG and XJYAO. We will change the cable connecting Quanterra Q330 and Baler and test at IGCSB. The outbreak of SARS in Beijing has slowed the deployment.

We will complete the installation of two final stations during the summer of 2003. The data, which is recorded in miniSEED format, will be converted into SEED format. Using the data collected by our network, we will begin locating earthquakes in the Huailai Basin and develop propagation effects for the basin, as well as model waveforms for source characterization. The assessment of intermediate-period surface waves from regional events such as that illustrated in Figure 7 will be used to constrain the crustal structure in the study area.

## **ACKNOWLEDGEMENTS**

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## **REFERENCE**

Stump, B., C. Hayward and R. -M. Zhou (2002). A comparative study of natural and man-induced seismicity in the Yanqing-Huailai basin and the Haicheng area, 24<sup>th</sup> *Seismic Research Review* □ *Nuclear Explosion Monitoring: Innovation and Integration*, 192-199.